(12) UK Patent Application (19) GB (11) 2 377 008 (13) A

(43) Date of A Publication 31.12.2002

(21) Application No 0115649.6

(22) Date of Filing 27.06.2001

(51) INT CL[7]
F27B 1/22, C21B 7/10, F27B 1/24, F27D 1/12 9/00

(52) UK CL (Edition T)
F4B B114 B129 B35C B35H

(56) Documents Cited
GB 2344639 A
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(58) Field of Search
UK CL (Edition T) F4B BFB BNB
INT CL[7] C21B 7/10, F27B 1/22 1/24 3/24 3/26, F27D 1/00 1/12 1/16 9/00
Other: Online: EPODOC, WPI, JAPIO

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(54) Abstract Title
Blast furnace cooling panel.

(57) A blast furnace cooling panel 1 comprises a metal backing plate 2, to which is secured a metal, preferably copper, cooling pipe 3 which has at least one outwardly extending fin 4 that is integrally formed with the pipe. In a first embodiment the fin 4 assists in catching slag and debris that circulates in the furnace during use, which protects the pipes and fins. In a second embodiment fin 4 assists in anchoring a refractory compound 9 in which the tubes and fins are embedded. The refractory material may be a cement-free refractory material containing no calcium aluminate cement and may be a colloidal silica refractory material. The backing plate 2 is preferably made of steel and may be copper clad steel, and the pipes 3 may be fixed to the plate with an interfacing pad 8 which may be of aluminium bronze material.

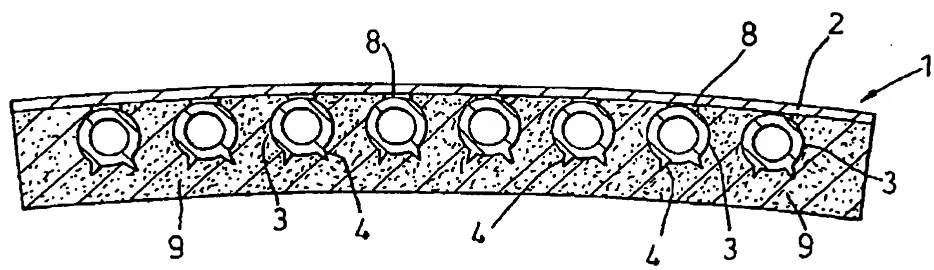

Fig. 3

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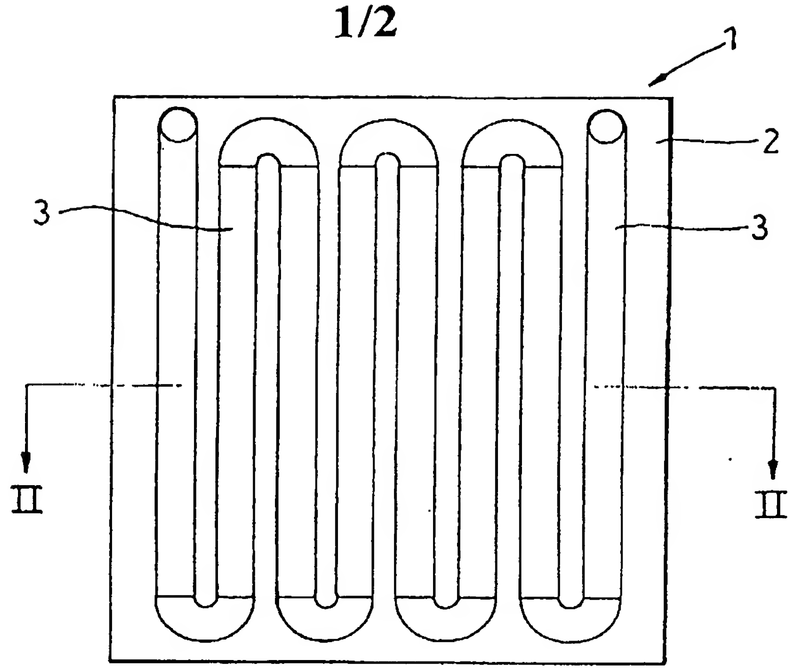

Fig. 1

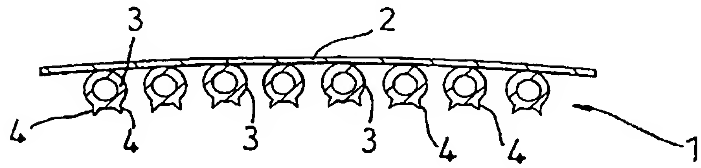

Fig. 2

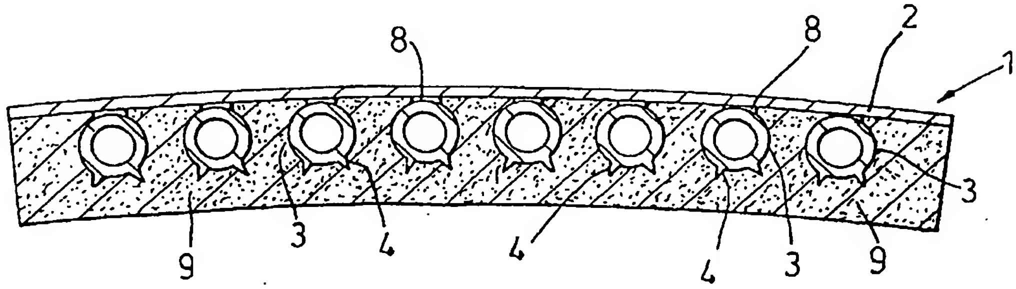

Fig. 3

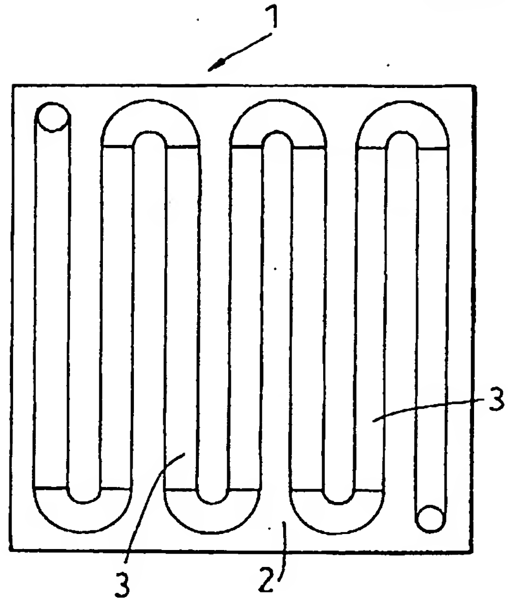

Fig. 4

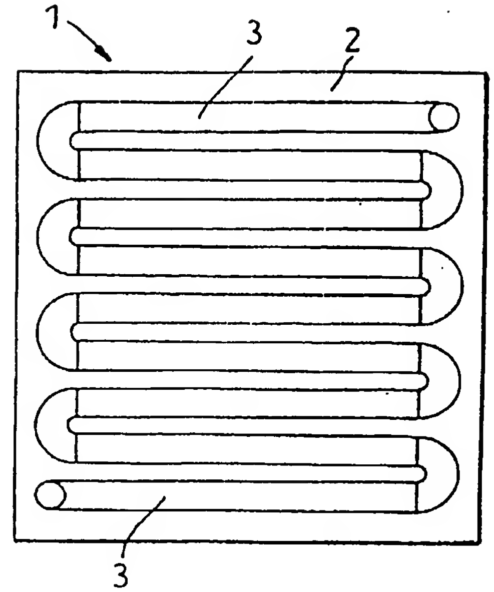

Fig. 5

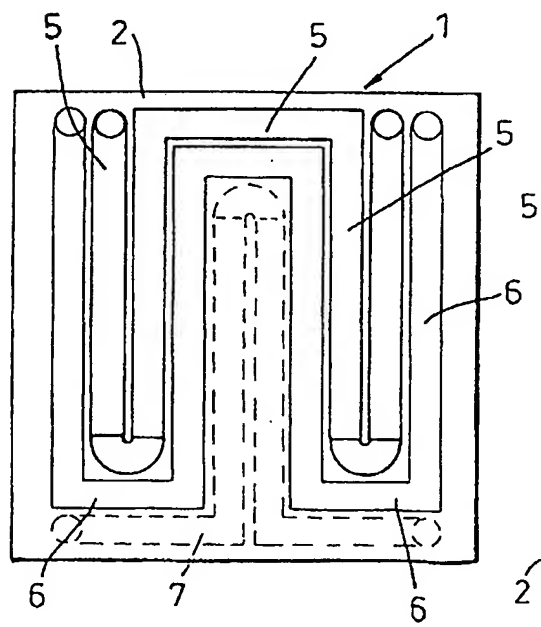

Fig. 6

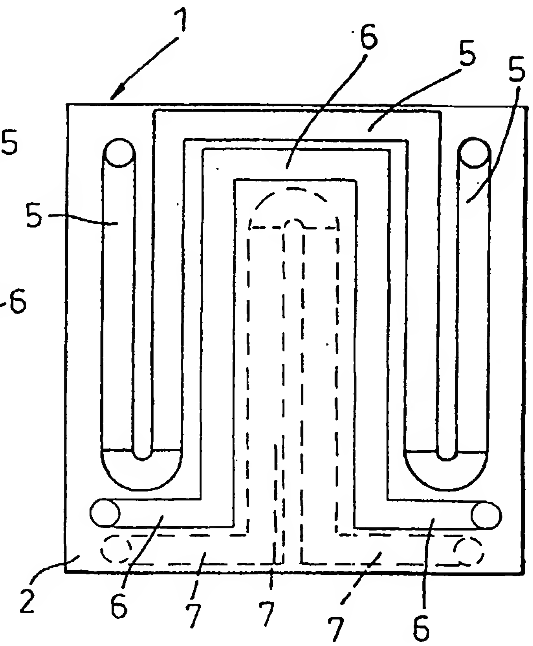

Fig. 7

A BLAST FURNACE COOLING PANEL

The present invention relates to a blast furnace cooling panel and in particular to a panel which can be used to replace part of the cooling system of a blast furnace.

Blast furnaces are cooled to reduce the operating temperature of the refractory lining and hence to lower the rate of chemical attack on the lining and thereby extend its working life; to protect the structural integrity of the load-bearing parts of the furnace shell; and to permit the use of metal parts for items such as tuyeres and hot blast valves where it is not possible to use refractory materials. Conventionally, two methods are used for cooling blast furnaces, namely plate coolers and stave coolers.

A plate cooler is built into the refractory lining of the furnace and comprises a cast, high-purity, copper block which is machined to provide channels through which water can be circulated. Typically, the plate is around 100 mm thick and the water channels are arranged to provide a good heat transfer by keeping the water velocity high in critical areas. Such coolers can be relatively easily replaced during the life of a furnace from the exterior of the furnace and are usually fitted with a steel flange which can be welded directly to the furnace shell to make a gas-tight seal. However, disadvantages of plate coolers include the fact that they are expensive because they are cast from solid copper blocks. In addition, as they are machined to provide the cooling channels, the dimensions of the block are limited to the maximum size of block which can be machined, that is typically around 2.5 m and the channels must be spaced apart significantly to prevent weakening of the block. Also, the machining process produces a large quantity of copper waste.

In contrast, stave coolers are usually made from cast iron or copper and are fitted inside a furnace between the outer steel shell and the refractory lining to form a continuous layer which protects the shell. Embedded in the casting are a number of cooling pipes, which are made using formers during casting. Rows of refractory bricks may also be set into the hot face of the casting to improve abrasion resistance and to reduce the rate of heat absorption. Disadvantages of such stave coolers include the fact that each typically comprises a cast 2m x 2m block which is between 180 and 400 mm thick. Hence, they can each weigh up to 3 tonnes. Replacing a stave cooler is also difficult as they must be fitted from inside the furnace. As blast furnaces are never allowed to cool significantly when once in use, the furnace must be cooled slightly by switching off the blowers for a few days before lowering in new staves from the top of the furnace. There is, therefore, significant downtime in the operation of the blast furnace during this process.

The object of the present invention is to provide a blast furnace cooling panel which provides more effective cooling than the conventional cooling arrangements described above and which is more cost effective to manufacture and to fit than these conventional cooling arrangements.

According to the present invention there is provided a blast furnace cooling panel comprising a metal backing plate to which is secured a metal cooling pipe which has at least one outwardly extending fin that is integrally formed therewith.

It will be appreciated that in the present invention, the cooling panel is made by fabrication rather being cast. This has the advantage that unlike the prior art, no costly machining operations are required to form the conduits for the cooling liquid. Instead, because the panel is fabricated,

a plurality of interconnected cooling pipes can be arranged as required to link into the cooling water circuit of any particular portion of a blast furnace. This enables the cooling pipes to be arranged much more closely together than can the machined channels of the prior art, which results in more efficient cooling. Also, the backing plate can be made in any shape to fit into the shell of a blast furnace where required.

Preferably, the cooling pipe and integral fin are made of copper.

Preferably, the panel comprises a layer of refractory material on one side in which the cooling pipe is embedded.

Preferably also, the refractory material comprises a cement-free refractory containing no calcium aluminate cement.

Advantageously, the refectory material comprises a colloidal silica bonded refractory material.

Preferably also, the thickness of the refractory layer is between 110 mm and 250 mm inclusive.

Preferably also, the cooling pipe and integral fin is made by extrusion.

Preferably also, the cooling pipe has an outside diameter of 82.5 mm and a wall thickness between 12 mm and 15 mm inclusive. The thickness of the backing plate is preferably between 16 mm 20 mm inclusive.

Preferably also, the fin runs longitudinally along the length of the pipe.

Preferably also, the cooling pipe comprises two outwardly extending fins that are integrally formed therewith. Advantageously, the fins extend from the pipe symmetrically on its side opposite the backing plate at an angle of 60° to one another.

Preferably also, the cooling pipe is bonded to the backing plate by means of an interfacing pad. Advantageously, the interfacing pad comprises an aluminium-bronze pad which is welded to the pipe before being welded to the backing plate.

Preferably also, the backing plate comprises a steel backing plate. Alternatively, the backing plate comprises a copper clad steel panel.

Preferably also, the backing plate is curved to follow the contour of the shell of a blast furnace where the cooling panel is to be installed.

The present invention will now be described by way of example with reference to the accompanying drawings, in which:-

Fig. 1 is a front view of a blast furnace cooling panel according to the invention;

Fig. 2 is a cross-sectional view along with line II-II in Fig. 1.

Fig. 3 is a cross-sectional view similar to Fig. 2 but of a second embodiment of panel and to an enlarged scale; and

Figs. 4, 5, 6 and 7 are a front views similar to Fig. 1 but showing alternative arrangements of cooling pipes.

In Figs 1 and 2, a blast furnace cooling panel 1 is shown comprising a metal backing plate 2 to which is secured a metal cooling pipe 3. The pip 3 has at least one outwardly extending fin 4 that is integrally formed therewith. The metal cooling pipe 3 can have any shape and in practice a plurality of interconnecting pipes 3, comprising straight lengths of pipe 3 interconnected by U-shaped elbows 4, are attached to the backing plate as shown in Fig 1 and Figs. 4 - 7. The pipes 3 are arranged over the surface of the plate 2 as desired to provide the required cooling effect and may form part of one or more separate water cooling circuits. Figs. 1, 4 and 5 show panels 1 where the pipes 3 are all interconnected to provide a single cooling circuit but in Figs. 6 and 7 are shown panels each with pipes 5 and 6 defining two water circuits respectively and room for attachment of a further set of pipes 7 to form a third cooling circuit.

The panel 1 of the invention is intended to be fitted either directly to the interior of the shell of a blast furnace by attachment of the backing plate 2 to the shell or, more typically, to replace a damaged or over-heating area of the shell directly. In the latter case, the damaged area of the shell is removed and a cooling panel according to the invention fitted in its place, with its backing plate 2 replacing the removed area of the shell. It will be appreciated that the backing plate 2 can be made in any shape or size to accomplish this purpose and incorporate appropriate attachment means around its edges to enable it to be welded into position. Also, the cooling pipes 2 can be provided in any configuration as desired to give the required degree of cooling and to link into the existing water cooling circuitry of the furnace. An additional advantage of this arrangement is that the panel can be fitted from the outside of the furnace.

The pipes 2 and integral fins 3 are made of copper by extrusion. As the pipes 2 must withstand the harsh conditions within the furnace, the cooling pipes have an outside diameter of 82.5 mm and a wall thickness between 12 mm and 15 mm inclusive as required. These thicknesses have been determined as those which provide the most efficient cooling whilst still remaining sufficiently thick to withstand operation within the furnace. Likewise, the thickness of the backing plate is typically between 16 mm and 20 mm inclusive and usually is made of steel or stainless steel with a curvature appropriate to follow the contour of the shell of the blast furnace where it is to be installed. In some applications the backing plate 2 may comprise a copper clad steel panel wherein a 4 mm copper coating is hot rolled onto the inner surface of the panel 2.

In all cases, the pipes 3 and associated elbows 4 are bonded to the backing plate 2 by means of an interfacing pad 8 (see Fig. 3). Advantageously, the interfacing pad 8 comprises an aluminium-bronze pad which is welded to the pipes 3 and elbows 3 before being welded to the backing plate 2.

The integrally extruded fin 4 of each pipe 3 runs longitudinally along the length of the pipe 3 and acts as a heat sink to assist in the conduction of heat away from surrounding region of the furnace and thereby assist in transmission of the heat to the cooling water circulating in the pipe 3. Preferably, each pipe 3 comprises two outwardly extending fins 4, as shown in Figs. 2 and 3, which extend from the pipe 3 symmetrically on its side opposite the backing plate 2 at an angle of 60° to one another.

In a first embodiment, as shown in Figs. 1 and 2, the fins 4 catch slag and debris which circulate in the interior of the furnace during use. This debris and slag settles in

layers over the pipes 3 and the fins 4 and helps to protect them from the highly abrasive and chemically destructive atmosphere in the furnace.

In this regard, it should be appreciated that the atmosphere inside a blast furnace is a reducing atmosphere which recovers oxygen from the iron being smelted and is thus highly corrosive. This is in contrast to the oxidizing atmosphere which exists inside an electric arc furnace where oxygen is used to burn the fuel and remove carbon from the iron.

In a second embodiment of panel 1, as shown in Fig. 3, the pipes 3 and their integral fins 4 are embedded in a layer of refractory material 9 which is applied to the interior side of the backing plate 2. In this embodiment the refractory material 9 is provided to protects the pipes 3 from the atmosphere of the blast furnace and in particular the corrosive reducing atmosphere. The fins 4 assist in anchoring the refractory layer 9 and also assist in drawing heat from it for transmission to the cooling water circulating in the pipes 3.

Preferably, the refractory material comprises a cement-free refractory containing no calcium aluminate cement. The reason for this is that most refractories utilize calcium aluminate cement (CAC) as the bonding material for holding the refractory aggregate together. The amount of CAC in the mix can vary from relatively low quantities to quantities of 10 % or more, depending on manufacturer and the mix. The refractory materials and cement are mixed with water to a proper consistency and installed in place. The added water reacts with the CAC forming hydrated phases that provide low temperature bonding of the refractory materials. At low temperatures the CAC materials are very dense and have very low permeabilities. However, as the refractory is heated, the

physical water is first driven off followed by the chemically bonded hydrated water. Because several hydration phases are present, complete dehydration occurs over a broad temperature range. As each hydration phase gives up its chemically bonded water, the bonding strength of the refractory decreases and its permeability and porosity increase until all water has been removed. Hence, such a refractory layer if used in a panel according to the invention would gradually break down and deteriorate in use.

To prevent such deterioration, the refractory layer 9 preferably comprises a colloidal silica bonded refractory material. Here a colloidal silica binder (not water) is mixed with the dry refractory materials and setting additives in the mix cause the material to gel and set at a controlled rate. This gellation is due to a condensation reaction that involves the release of water. Unlike CAC bonding that involves the production of chemically bonded water, the colloidal silica bonded material liberates chemically attached water. Thus the silica bonding involves the formation of a chemical bond that does not breakdown through dehydration as the material is heated. As a result, the refractory layer 9 does not deteriorate when in use within a blast furnace. Also, such a refractory layer 9 does not define capillaries or other passages which therefore, blocks the passage of corrosive and other harmful gases through the layer 9 and thereby protects the pipes 3 and the backing plate 2.

The thickness of the refractory layer can vary dependent on the cooling capability of the panel 1. This is dependent on the rate of water flow through the pipes 3 and on the spacing and arrangement of the pipes 3 on the panel. It is expected that the thickness of the refractory layer may vary between 110 mm and 250 mm dependent on the application. In all cases this results in a panel 1 which is considerably

thinner than a conventional cooling panel or stave. In view of this, if cooling panels according to the invention are used throughout a blast furnace then the working volume of the blast furnace is increased, thus increasing its operating throughput and with a subsequent reduction in operating costs.

The optimum design of cooling panel is one which will satisfy the operating conditions that the furnace shell is retained at a temperature less than 100°C and the maximum temperature of the inner face of refractory layer 9 remains below 1000°C: Dependent on the particular operating conditions and design of blast furnace in question including the rates of water flow through its water cooling circuits, mathematical models can be constructed to emulate various designs of panel 1 having different thickness and arrangements of pipes 3 and with different refractory layer thicknesses. The optimum configuration of panel 1 can then be decided on for the blast furnace in question prior to construction.

CLAIMS

1. A blast furnace cooling panel comprising a metal backing plate to which is secured a metal cooling pipe which has at least one outwardly extending fin that is integrally formed therewith.

2. A panel as claimed in Claim 1, wherein the cooling pipe and the integral fin are made of copper.

3. A panel as claimed in Claim 1 or Claim 2, wherein the panel comprises a layer of refractory material on one side in which the cooling pipe is embedded.

4. A panel as claimed in Claim 3, wherein the refractory material comprises a cement-free refractory containing no calcium aluminate cement.

5. A panel as claimed in Claim 3 or Claim 4, wherein the refectory material comprises a colloidal silica bonded refractory material.

6. A panel as claimed in any one of Claims 3 to 5, wherein the thickness of the refractory layer is between 110 mm and 250 mm inclusive.

7. A panel as claimed in any one of Claims 1 to 6, wherein the cooling pipe and integral fin is made by extrusion.

8. A panel as claimed in any one of Claims 1 to 7, wherein the cooling pipe has an outside diameter of 82.5 mm and a wall thickness between 12 mm and 15 mm inclusive.

9. A panel as claimed in any one of Claims 1 to 8, wherein the thickness of the backing plate is between 16 mm 20 mm inclusive.

10. A panel as claimed in any one of Claims 1 to 9, wherein the fin runs longitudinally along the length of the pipe.

11. A panel as claimed in any one of Claims 1 to 10, wherein the cooling pipe comprises two outwardly extending fins that are integrally formed therewith.

12. A panel as claimed in Claim 11, wherein the fins extend from the pipe symmetrically on its side opposite the backing plate at an angle of 60° to one another.

13. A panel as claimed in any one of Claims 1 to 12, wherein the cooling pipe is bonded to the backing plate by means of an interfacing pad.

14. A panel as claimed in Claim 13, wherein the interfacing pad comprises an aluminium-bronze pad which is welded to the pipe before being welded to the backing plate.

15. A panel as claimed in any one of Claims 1 to 14, wherein the backing plate comprises a steel backing plate.

16. A panel as claimed in any one of Claims 1 to 15, wherein the backing plate comprises a copper clad steel panel.

17. A panel as claimed in any one of Claims 1 to 16, wherein the backing plate is curved to follow the contour of the shell of a blast furnace where the cooling panel is to be installed.

18. A blast furnace cooling panel substantially as described herein with reference to Figs. 1 and 2, Fig. 3 or any one of Figs. 4 to 7.

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Application No:	GB 0115649.6	**Examiner:**	Robert Barrell
Claims searched:	1-18	**Date of search:**	16 April 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): F4B (BNB, BFB)

Int Cl (Ed.7): F27B (1/22, 1/24, 3/24 & 3/26),
F27D (1/00, 1/12, 1/16 & 9/00)
C21B (7/10)

Other: ONLINE: EPODOC, WPI & JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,Y	GB 2344639 A	BRITISH STEEL, see: figs 7 - 8 and pages 5 - 6 - pipes cast with fins and plate, in copper; fig 9 - curved plate.	X: 1, 2 & 17 Y: 15
XE	WO 01/63193 A1	AMERIFAB, see: figs 1 - 6 - configuration; page 1, 6 - 7 - 'metallurgical furnace' page 10, 9-12 - refractory slag coating; page 9, 18-22 - integral fins, extrusion; page 9, 6 - 7 - fin angles.	1, 3, 7 & 10 - 13.
X,Y	US 4097679	FUKUMOTO et al., see: figs 4- configuration; column 3, 51-54 - cast copper, refractory layer; column 4, 3 - 6 - thickness of refractory layer; fig 5 - curved backplate.	X: 1 - 3, 6 & 17. Y: 15
Y	GB 2129919 A	VSESOJUZNY et al., see: figs 1- 4 & page 2, 91-95 - steel material.	15
Y	US 4455017	WUNSCHE, see: figs and columns 7 - 9 - fins on pipes, pipes welded to plate (7), curved section, refractory layer.	15

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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Application No: GB 0115649.6
Claims searched: 1-18

Examiner: Robert Barrell
Date of search: 16 April 2002

Category	Identity of document and relevant passage	Relevant to claims
A	US 4351055 BICK et al, see: fig 4 & column 4, 46-48 - tubes and fins integrally formed.	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.